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NEARLY twenty years ago I learned from Dr. Thomas Keith his method of treating the pedicle, in ovariotomy, by the clamp and cautery, and I have had ample opportunities to observe that the results are vastly superior to those obtained by any other method. Within the past three years I have discovered that the same method of closing bleeding vessels is applicable in all surgical operations. At the same time I have found that it is no easy matter to use the means which give such excellent results. Naturally, this inclined me to seek some simpler, easier way of accomplishing the same object—that is, to arrest bleeding in surgical operation. Hitherto the difficulty in using compression and heat to arrest hæmorrhage occurred in the management of the heat element.

The process is as follows: A portion of the end of the vessel, or mass of tissue containing bleeding vessels, is seized in a forceps or clamp and firmly compressed, and while under pressure heat is applied to the instrument to desiccate or dry the parts but not to

char them. In this way the walls of the arteries become united and hæmorrhage is certainly prevented. Heretofore the heat was obtained by applying a heavy cautery iron (heated in the fire) to one side of the clamp, but this rendered the procedure difficult and unsatisfactory and limited it to the treatment of the pedicle in ovariotomy.

With the determination of improving the process and adapting it to the arrest of hæmorrhage in all surgical operations, I employed electricity to produce the required heat and devised instruments to meet all requirements. Now I have perfected the method so that I believe it to be worthy of the attention of the medical profession.

The advantages which may be fairly claimed for this way of controlling bleeding in surgery are, that it is certain and reliable in closing isolated vessels or those imbedded in masses of tissue, like an ovarian tumor pedicle for example. At the same time that bleeding is arrested all lymphatics are sealed up, which prevents septic absorption. Nerves that accompany the vessels are immediately and completely devitalized, and hence there is less pain and irritation in the stump. The heat employed sterilizes the parts involved, and therefore the operation is perfectly aseptic. Of these many advantages, the greatest, I believe, is that it leaves the stump of a pedicle or the end of an artery in a condition requiring the least reparatory care, so that recovery is more prompt and uneventful. My impression is that the ends of vessels and tissues of pedicles treated in this way become first hydrated and then organized (during the healing process), in the same way that an inflammatory exudate upon a serous membrane becomes

vitalized. I asked Dr. Keith about this. He said that he did not know exactly what became of the stump of the pedicle treated in his way, but he did know very surely that it gave no trouble or anxiety to patients or the surgeon. In this my experience fully agrees with his. I have never known trouble of any kind to occur after an operation that could be attributed to this method of controlling hæmorrhage. No such results can be obtained with the ligature. Even the modern ligature, that is (with much care and trouble made) aseptic and can be left in the tissues, has its faults and shortcomings. The catgut ligature is very difficult to sterilize and keep surgically clean, and it is liable to slip and permit hæmorrhage. In being disposed of by absorption, or being walled in or encysted, it causes more or less irritation. Dead animal tissue, though sterile, can not be taken care of in a wound without causing some disturbance.

Silk, or unspun silk, called silkworm gut, properly prepared, will not decompose, and being less likely than catgut to slip has some advantages, but is more objectionable still because it causes irritation, and in the effort to escape or be thrown out enters the abdominal or pelvic viscera and does great damage. There are many cases recorded of serious trouble from ligatures of this kind long after recovery from operations.

Although fully satisfied with the results obtained by compression and heat as a hæmostatic, I have long been annoyed by the practical difficulties in its employment, as already stated. While thinking of how to overcome these difficulties, my attention was called to the use of electricity in cooking and heating laundry smoothing irons. It then occurred to me to adapt the same

heating power to surgical instruments, such as the clamp and forceps.

My requirements in this regard were explained to Louis M. Pignolet, an electrician who had given much attention to electricity as used in medicine and surgery. He at once took up the study of the subject with enthusiasm and soon produced the instruments and appliances required. He first made an artery forceps, then a clamp, and finally a full set of compression forceps. I should say he adapted the system of electric heating to these instruments, which enabled me to employ the method to the control of bleeding in all surgical operations.

The following is Mr. Pignolet's description and illustrations of the instruments in question:

"The artery forceps, as shown in Fig. 1, is provided with two thin and narrow platinum plates which

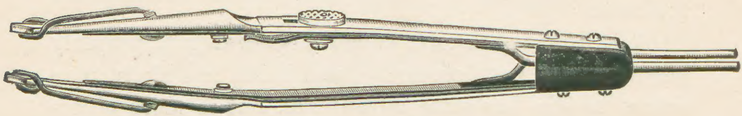

FIG. 1.

cross the inner sides of the blades at their distal ends and are heated by an electric current conveyed to them through copper wires. One plate is attached to each blade as close to its end as possible, so that when the forceps is closed the plates coincide with each other. The plates are insulated from the forceps by pieces of mica, and one end of each passes around the edge of the forceps blade and is fastened to its side. The other end of the plate passes around the opposite edge without touching the blade and connects with a thick cop-

per wire, which is insulated from the forceps and extends along the top of the blade for about a third of its length. At this point the wire passes through an insulating bushing in the blade and connects with an insulated strip of sheet copper running beneath the blade to the end of the forceps. The blades are electrically connected together at the end of the forceps, but an intervening piece of hard rubber insulates the copper strip on one blade from that on the other. Terminals are fixed to the ends of the copper strips for making connection with flexible conductors for conveying the electrical current to the forceps. When the terminals are connected to a suitable source of electricity the current flows along one of the copper strips and its wire to one of the platinum plates, thence through the plate to the forceps, and thus to the other platinum plate, returning through the remaining copper strip and wire. The current is turned off and on by a switch on the forceps operated by sliding a knob."

In perfecting the compression forceps and clamp, which were constructed subsequently to the artery forceps, the discovery was made that it was only necessary to have the heating surface on one side. Therefore the artery forceps may be constructed with but one platinum plate on one of the blades only.

The method of heating the artery forceps, though simple, is not applicable to larger instruments like the compression forceps described below; therefore a different method is employed for such a forceps, which is heated by the passage of an electric current through a wire of suitable resistance inclosed in a water-tight chamber in one of the jaws of the instrument.

The construction is plainly shown by the illustra-

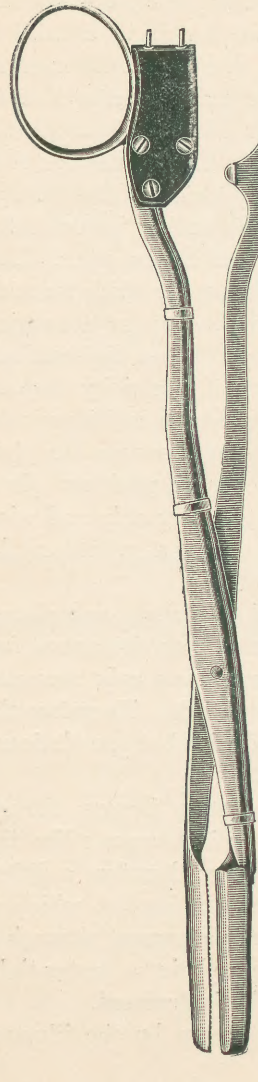

Fig. 2.

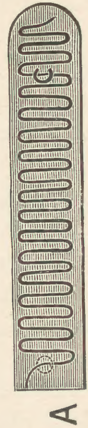

Fig. 4.

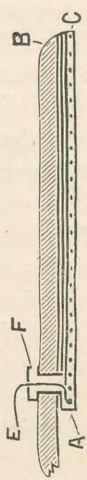

Fig. 3.

tions, of which Fig. 2 is a side view of the forceps, Fig. 3 is a section of the jaw on an enlarged scale, and Fig. 4 is a top view of the chamber in the jaw, also on an enlarged scale, showing the arrangement of the heating wire. The chamber is formed by attaching a flat case (A) of sheet metal to the inner side of one of the jaws (B) of an ordinary compression forceps, in such a manner as to form a water-tight chamber. This increases the size of the jaw but little, as the case is less than an eighth of an inch deep and has the same length and width as the jaw, so that the instrument appears like an ordinary compression forceps.

The wire (C) for heating the sheet metal face of the jaw is of platinum or other suitable metal, and zigzags back and forth from side to side in passing through the chamber. A fireproof material, which is also an electrical insulator, separates and insulates the wire from the sides of the chamber. The space between the wire and the back of the chamber is several times greater than that between the wire and the front, so that the heat from the wire can pass much more easily to the front than to the back. One end of the wire is electrically connected to the instrument and the other to a copper wire, E, passing out of the chamber through an insulating bushing, F, in the back of the jaw. The copper wire extends back to the handle of the instrument and is insulated by a waterproof covering. Terminals are provided at the end of the copper wire and the handle of the forceps for making connection with the flexible wires or cables which convey the electric current to the instrument. The path of the current is through the copper wire, the wire in the chamber, and one blade of the forceps. The copper wire and the blade present but

little resistance to the electricity and are but slightly (if appreciably) heated by the passage of the current. On the other hand, the wire in the chamber offers considerable resistance to the current and is heated by it to a greater or less degree, according to the strength of the current and the resistance of the wire.

By this method of construction the heat is concentrated upon the inner surface of the jaw of the forceps or clamp—the mechanism of which remains precisely the same—and but little is expended uselessly in heating the other parts of the instrument. The electrical energy necessary for heating the jaw is therefore reduced to the smallest possible quantity, and varies from ten to thirty watts, according to the size of the forceps.

The required degree of heat, which varies from 170° to 190° F., is attained very quickly, owing to the closeness of the heating wire to the face of the jaw and the thinness of the sheet metal composing the face. Another advantage is the even distribution of the heat over the face of the jaw, owing to the many zigzags of the heating wire. Furthermore, as the chamber is water-tight, the instrument can be cleansed in an antiseptic solution without damage.

On this principle forceps of various shapes, from the largest to the smallest sizes, can be heated, as the general formation of the instruments is not modified by the heating attachments. Artery forceps have also been heated in the same way.

The current can be switched on and off by a switch mounted on the instrument or located in the circuit leading to it.

The method of construction described is advan-

tageous, for it simplifies the instrument by dispensing with the extra copper wire that would be required if one end of the heating wire were not connected to the forceps; but if desired the heating wire may be connected to a second insulated copper wire so that no current would flow through the blades of the forceps.

As the forceps requires less electrical energy than the average cautery electrode, the current from a small storage battery or a suitable primary battery, such as the excellent battery of Dr. Byrne, can be used for heating it, but the current from electric-light mains is preferable, as it is not subject to failure, and the care and attention necessary to keep a battery in working order are avoided. The strength of the current can be easily regulated to suit any forceps by means of a small rheostat.

Alternating current of the pressure used for lighting buildings can be converted into a current of lower pressure adapted for the forceps, as well as cautery knives and examining lamps, by means of a small transformer capable of giving currents of different strengths and pressures. This can be accomplished by a switch, by which a part of the turns of the wire composing the secondary of the transformer can be cut in or out of circuit a few at a time to avoid considerable changes of current strength in moving the switch from one point to another.

When the current from the lighting mains is continuous instead of alternating, it can be converted into alternating current for operating transformers like those described, by means of a small dynamomotor.

In the treatment of the pedicle of ovarian tumors I employ the improved clamp invented by me a number

of years ago (see Fig. 5), with the electrical heating attachment. The clamp compresses the pedicle on four sides. The long blades keep the tissues from spreading, while the short, sliding blade presses the tissues against the other cross-bar. The advantage of this is that the pressure upon the pedicle is equal at all points, and it thereby gives a smaller stump. The trouble with the old straight clamp is that it spreads out the pedicle too

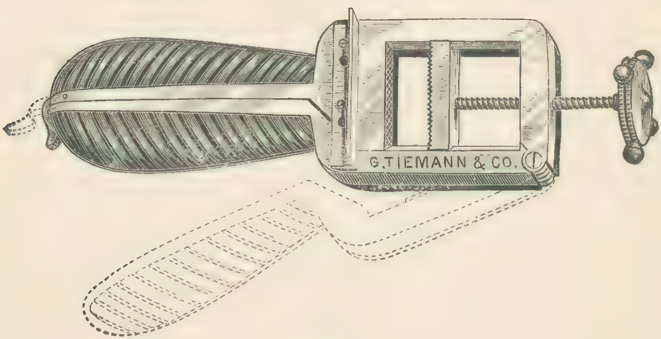

FIG. 5.

much, and while it firmly holds the central or thickest part, the outer edges are liable to slip out of its grasp.

A more detailed description of my experience with the method may now be given.

In the management of the instruments the heating power should be tested before beginning to operate. The amount of heat required varies, of course, according to the instrument used and the size of the artery or pedicle to be treated. The adjusting of the current requires a knowledge of the source of the power—that is, the management of the current as obtained from the electric-light mains, storage battery, or the Byrne pri-

mary battery. These sources of the electric currents are familiar to surgeons, so that a very little practice will suffice to master this part. In ovariotomy the clamp should be attached to the electric power and heated to the required degree in order to ascertain that the appliances are all in good order. If possible, the clamp should be applied to the pedicle and moderately tightened before separating the tumor, and in dividing the pedicle a portion should be left projecting beyond the clamp to provide against slipping. When the current is turned on, and as the tissues shrink from the heat, the clamp should be tightened more.

Before removing the clamp, and while the current is still going, the clamp should be loosened a trifle, and the portion of tissue projecting beyond the clamp cut off. This permits the clamp to slip off without pulling the pedicle apart. The tissues may stick to the jaws of the clamp, and if they are opened too far the compressed desiccated portion may be pulled apart and start bleeding—hence the necessity of removing the clamp as directed. In order to prevent the pedicle from falling into the abdomen when the clamp is removed, it should be seized on one or both sides with forceps and held in view for inspection and further treatment if necessary. If the treatment has not been sufficient the blood will be seen forcing its way along the artery, advancing a little with each pulsation. In that event the clamp should be reapplied and the current turned on to complete the desiccation. There is no time lost in making this inspection of the stump, because it gives time for the heated parts to cool down so that the stump can be safely dropped back into the abdominal cavity. This description of the use of the clamp and cautery in

ovariotomy is about the same as that given to me by Keith, excepting the use of the electricity for heating.

Vaginal hysterectomy offers superior opportunities for this method of arresting hæmorrhage. I have tried every known method of doing this operation and found them all objectionable, and so I was led to do the operation as follows:

The vagina is divided all round the cervix uteri with the cautery knife. The bladder is separated from the uterus and the peritonæum opened in front and behind in the usual way. The lower portion of the broad ligament is then seized with the compression forceps as close to the uterus as possible and the heat turned on. The compression is increased while the heat is being applied. A little practice is needed in order to know the degree of heat that is being used and the length of time that it should be continued. When one is doubtful about this the forceps may be removed and the parts inspected, and if need be the forceps should be reapplied and the heat continued long enough to obtain the desired effect. The ligament is divided with knife or scissors between the forceps and the uterus as far up as the vessels have been closed. The lower portion of the ligament on the other side is treated in the same way. The uterus is drawn down and the remaining portions of the ligaments are treated in sections until the uterus is completely made free. The operation may be briefly described by saying that it is performed in the same way as when forceps are used to control the bleeding, with the difference that instead of leaving the forceps on long enough for the compression alone to arrest the hæmorrhage the heat completes the hæmostasis and the forceps are removed at once.

In controlling hæmorrhage from small arteries my observations have been limited to such operations as amputation of the mammary gland and small vessels in divided adhesions in abdominal operations. The forceps is in form the same as the ordinary artery forceps, and is used in the same way. The artery is seized and held firmly, and the electrical connection made and continued until the end of the compressed vessel is desiccated.

This takes very little more time than applying a ligature; in fact, it takes less time when the vessel is in a deep cavity and not easy to get at. In the management of small bleeding vessels in the abdomen or down in the pelvic cavity this electrically heated forceps is very useful and convenient, and saves much time, trouble, and anxiety.

Up to the present time I have not practised this method of controlling the hæmorrhage in doing abdominal hysterectomy, but I am confident that it can be employed satisfactorily in that operation.

The following cases reported from my clinic by Dr. Todd are given as illustrative of this method of controlling hæmorrhage:

CASE I.—Miss M., aged fifty-four years, native of the United States. Ten months ago she noticed a small nodule in the left breast which grew rapidly and became very painful. She lost flesh, became anæmic and cachectic, and lately had noticed a swelling in the left axilla.

Diagnosis.—Malignant disease of the left breast, with axillary involvement.

Treatment.—Field of operation prepared in the usual way and the usual incision made. Hæmorrhage was free, but was quickly and easily controlled, the method

being as follows: All bleeding points were seized with the hæmostatic forceps; a forceps was then connected with the battery and current turned on until the desired desiccation was obtained; this was continued for from half a minute to a minute, depending upon the size of the vessel; then the next forceps was similarly connected, the former remaining *in situ*, thereby gaining the greatest hæmostatic power without loss of time. The axillary glands were removed and the hæmorrhage controlled in the same way. The wound was closed with waxed silk and dressed with carbolized gauze (carbolic acid, one part; glycerin, eight parts). Time consumed in operation, thirty minutes. Convalescence rapid and progressive. Highest temperature, 100.4° F. right after operation; the following morning, 100° F.; from that time below 99.2° F.

No anodyne was necessary during recovery. Morphine sulphate, an eighth of a grain, atropine sulphate, one two-hundredth of a grain, were given hypodermically before consciousness was gained after ether, as is our custom, to allay restlessness. Sutures removed on seventh day; union perfect. Sat up on eighth day and left for home in three weeks.

Case II.—Entered L. I. C. Hospital, September 21, 1896. D. G., native of Norway and single, began to menstruate at thirteen years and regular. Ten months ago came to this country; had amenorrhœa for three months, then menstruated with severe pain for one day; since then menses have been normal.

One month prior to admission was seized with severe pain in the left ovarian region, which gradually extended to the right and across the back. At this time there was a profuse yellowish discharge from the vagina, together with painful and frequent micturition.

Diagnosis.—Pyosalpinx (double).

Treatment.—September 27, 1896, abdomen was opened, the ovaries and tubes were freed from adhesions, and the broad ligament pedicle on either side seized with

the long compression forceps, current turned on, and continued for two minutes and a half. The tube and ovary were amputated, when hæmostatic forceps were removed and there was no hæmorrhage. A number of bleeding points deep down in the pelvis were treated by the method in question. Abdomen was closed with silk. Time consumed in operation, twenty-five minutes.

Convalescence progressive and uneventful. Temperature on third day, 100.5° F.; pulse, 102. This was the highest temperature until the sixteenth day, when it was 102° F.; the next morning it was down to normal. Cause of rise unknown. Sutures removed on the eighth day; primary union.

Left hospital three weeks after operation.

Case III.—Entered L. I. C. Hospital, giving following history: Thirty years of age, married five years, never been pregnant. Menses began at thirteen years, regular, flow lasting three days, and profuse.

Three months ago she noticed a profuse yellowish and slightly blood-tinged discharge from the vagina, accompanied by painful and frequent micturition. One week prior to admittance she was seized with a sharp pain in both ovarian regions, which continued up to time of operation.

Diagnosis.—Double pyosalpinx.

Treatment.—The operative technique of this case was similar in all respects to that of the former one. Highest temperature, 100° F.; pulse, 94. This was on the seventh day, the day upon which the sutures were removed; thereafter it was below 100° F. Primary union was obtained in the wound, and the patient left the hospital on the twentieth day after operation.

Case IV.—Mrs. E., aged forty-three years, native of the United States. Married eighteen years, four children, no miscarriages. Menses began at fifteen, and she has always been regular in all respects. She came to hospital stating that five years previous she fell from a ladder and since then she has had backache, pelvic tenesmus, and frequent and difficult urination. Also com-

plained of a mass protruding from the vulva, which made locomotion difficult and painful. Diagnosis of complete procidentia was made. The uterus was about six inches in length, cervix eroded from contact with clothing, and the ligaments infiltrated and thickened. Vaginal hysterectomy was decided upon. Patient anæsthetized and in the lithotomy position. Uterus was seized with a double tenaculum, and the anterior and posterior vaginal walls were opened with serrated scissors, all bleeding points being controlled with the cautery, as previously described; then the broad ligaments were seized in the grasp of the large forceps and connected, two minutes and a half being allowed for mummification; then they were removed, care being taken not to tear open the edges in doing so; ordinary clamps applied to the uterine side and uterus amputated. Hæmorrhage was completely controlled. Suturing the anterior and posterior walls to the peritonæum and packing cavity with gauze completed the operation.

During convalescence she was entirely free from pain, and urinated voluntarily after the first twenty-four hours. Bowels moved on third day. Vaginal discharge was absent on tenth day. Temperature never rose above 99.5° F., and patient left in three weeks.